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Comment on wcd-2022-43

Jonathan Day (Referee)

Referee comment on "The role of Rossby waves in polar weather and climate" by Tim Woollings et al., Weather Clim. Dynam. Discuss., https://doi.org/10.5194/wcd-2022-43-RC3, 2022

Summary

This paper presents a theoretical discussion, with illustrative examples, of the role of Rossby waves in polar meteorology. It is a timely piece of research, since there have been a large number of studies aiming to infer the dynamic response of the Atmosphere to polar amplification as well as increased focus on providing skillful weather forecasts for the polar regions, where skill has typically been lower than in mid-latitudes. However, relatively few studies have attempted to put the large-scale atmospheric dynamics of the polar regions on a more theoretical footing.

I really enjoyed and learned a lot from reading this paper, however I think there are areas where it could be improved prior to publication, and I have made some specific suggestions below. My one concern with the paper was a tendency in the paper for arguments and analyses to ignore the seasonality which is large in polar areas leading to dramatic differences in large scale atmospheric structure and phenomena. This is touched on in the description of Figure 4, but I belive the manuscript would be improved by exporting this discussion of the implications to other sections.

Regarding seasonality, the environmental conditions in the polar regions are very different in DJF than JJA. For example although the Arctic atmosphere is stably stratified in winter almost 100% of the time, in the summer particularly over land it is only stably stratified about 50% of the time and inversions are much weaker when they occur (Serreze et al., 1992; Serreze and Barry, 2009). It made me wonder whether the potential for convection to trigger a Rossby wave response over continental regions of the Arctic in summer had been overlooked.

We also see very different dynamic behaviour in different seasons. i.e. very long-lasting large-scale tropospheric vortices in the summer, but smaller, shorter more intense

vortices in winter (Vessey et al., 2022). Given that these differences exist I think the discussion should been revised to be more careful to mention to which season specific arguments apply to and not to jump between seasons when comparing figures. I will point out where I think this is an as issue in the text below.

Specific comments edits:

L2: involves to involve

L70: I would suggest removing the slightly tangential remark about the sea ice as the information content in the paper is already quite high.

L80: If I understand correctly the difference in theta gradients shown in Figure 4 around the 65-75 band between DJF and JJA suggest quite different potential for Rossby wave propagation. It makes me wonder if interpreting Fig 2 with FIG 1 is meaningful. I suggest including the e-folding timescales for JJA in Fig 2 as well.

L85: change "in timescale in the observations" to "in the e-folding timescale of the observations"

L273: This increase in temperature gradients coincides with the appearance of the Arctic frontal jet (Serreze et al., 2001; Crawford and Serreze, 2014; Day Jonathan J. and Hodges Kevin I., 2018) which I think is important to mention here. Recent studies have discussed the co-occurrence of quasi stationary waves and what they call "double jet" occurrence in high latitudes (e.g. Kornhuber et al., 2017). There is a bit of a disconnect in the literature produced by these different groups and it might be a good opportunity say something about this as well.

L337: Vessey et al (2022) quantify this in a systematic way over many cases showing by selecting the 100 most intense Arctic and N Atlantic storms and find the mean lifetime for these is 5.4 days for NA-DJF, 6.1 days for Arctic-DJF and 9.7 days Arctic-JJA.

Section 6: It' probably important to mention that this section is really describing the situation in winter. In summer, from a thermodynamic perspective the position of the sea ice has much less of an influence on the turbulent exchange. Also the arguments related to static stability in the paragraph starting on L446 are most relevant for winter as already mentioned.

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